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REPORT

ON

ELSWORTH LAKE

CADDO AND COMANCHE COUNTIES

OKLAHOMA

EPA REGION VI

WORKING PAPER NO. 583

WITH THE COOPERATION OF THE

OKLAHOMA DEPARTMENT OF POLLUTION CONTROL

AND THE

OKLAHOMA NATIONAL GUARD

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16. ABSTRACT:

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT ON ELSWORTH LAKE

CADDO AND COMANCHE COUNTIES, OKLAHOMA

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

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CONTENTS

	Page
Foreword	ii
List of Oklahoma Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	6
IV. Nutrient Loadings	12
V. Literature Reviewed	18
VI. Appendices	19

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Oklahoma Department of Pollution Control for professional involvement, to the Oklahoma National Guard for conducting the tributary sampling phase of the Survey, and to those Oklahoma wastewater treatment plant operators who provided effluent samples and flow data.

Dr. Denver Talley, Director, Oklahoma Department of Pollution Control; the staff of the Oklahoma Water Resources Board; and the staff of the Oklahoma State Department of Health reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

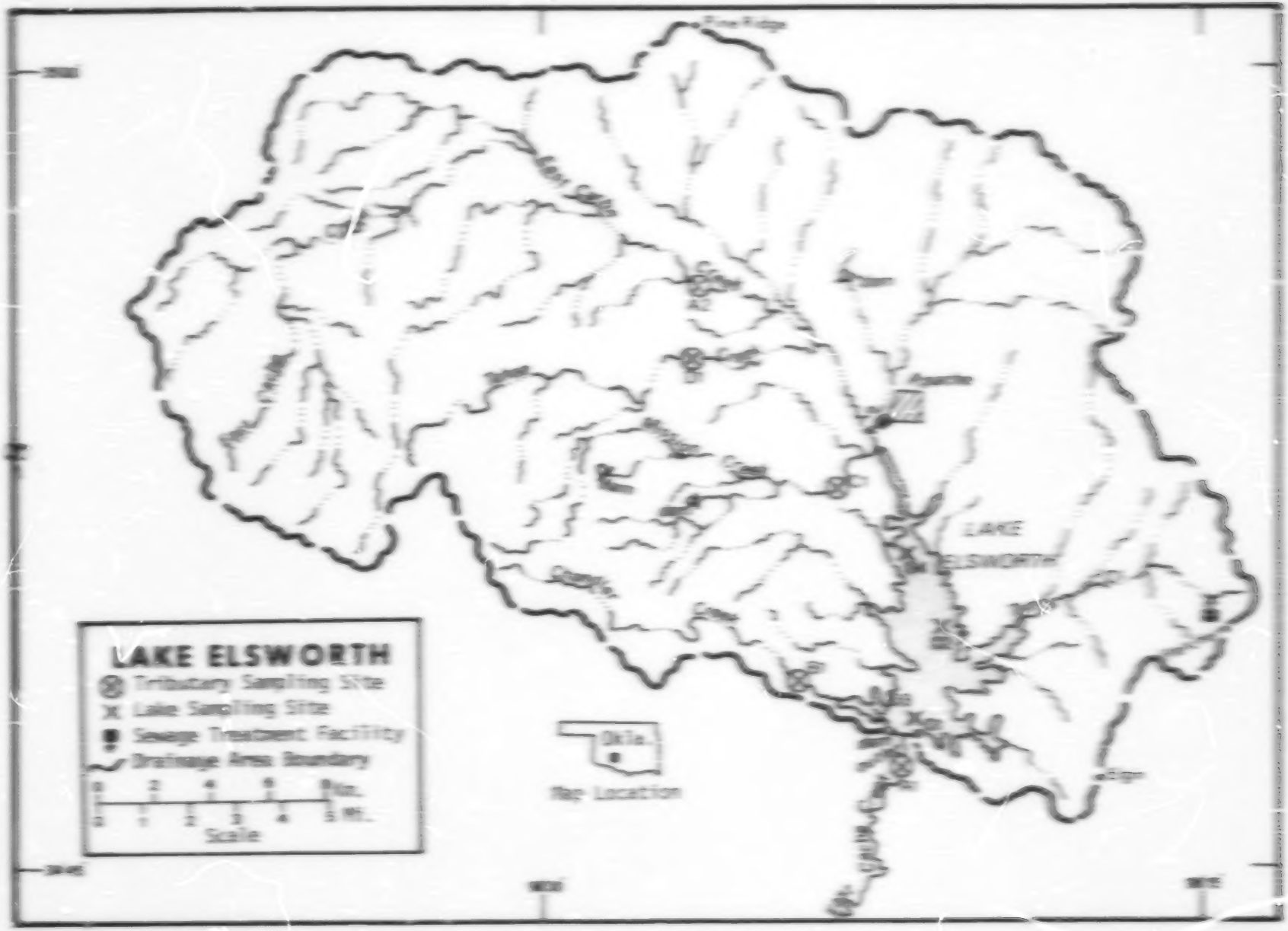
Major General John Coffey, Jr., the Adjutant General of Oklahoma, and Project Officers Colonel Curtis W. Milligan and Major James O. Haney, Jr., who directed the volunteer efforts of the Oklahoma National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OKLAHOMA

LAKE NAME	COUNTY
Altus Reservoir	Greer, Kiowa
Arbuckle Lake	Murray
Lake Elsworth	Caddo, Comanche
Lake Eufaula	Haskell, McIntosh, Okmulgee, Pittsburg
Fort Cobb Reservoir	Caddo
Fort Supply Reservoir	Woodward
Foss Dam Reservoir	Custer
Lake Frances	Adair
Grand Lake O' The Cherokees	Mayes, Delaware, Craig, Ottowa
Lake Hefner	Oklahoma
Keystone Reservoir	Tulsa, Creek, Osage, Pawnee
Oologah Lake	Nowata, Rogers
Tenkiller Ferry Reservoir	Cherokee, Sequoyah
Lake Thunderbird	Cleveland
Wister Reservoir	Leflore


LAKE ELSWORTH
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Scale
LAKE
ELSWORTH
Okla.
Map Location

REPORT ON ELSWORTH LAKE, OKLAHOMA

STORET NO. 4003

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that Elsworth Lake is eutrophic, i.e., nutrient rich and potentially highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by the actual or potential impact upon designated beneficial water uses of the lake.

Of the 16 Oklahoma lakes (including Texoma Lake) sampled in 1974, 12 had higher median total phosphorus levels, 13 had higher median inorganic nitrogen values, and 13 had higher median orthophosphorus levels than Elsworth Lake. Chlorophyll a levels in the lake ranged from 1.5 µg/l in June to 21.0 µg/l in October, with a mean of 8.4 µg/l. Potential for primary production as measured by algal assay control yield was low during spring collection, and Secchi disc transparency was poor.

Survey limnologists did not observe any problem algal blooms or aquatic macrophytes in Elsworth Lake during the sampling year.

*See Appendix E.

B. Rate-Limiting Nutrient:

The lake data (ratios of inorganic nitrogen to orthophosphorus) suggest primary limitation by nitrogen during the April and October sampling periods, but phosphorus limitation during June.

C. Nutrient Controllability:

1. Point sources -

It is calculated that known point sources contributed 36.0% of the total phosphorus load to Elsworth Lake during the sampling year. The Apache plant contributed 33.1% of the total phosphorus load, and the Fletcher plant contributed 2.9%.

During the 1974 sampling year, the lake received a total phosphorus loading greater than that proposed by Vollenweider (1975) as an "oligotrophic" loading but less than his "eutrophic" loading values (Section IV-F). Although Vollenweider's model may not be applicable to highly turbid water bodies, elimination of known point sources would reduce loading to an "oligotrophic" level and substantially lower the potential for the occurrence of nuisance conditions in Elsworth Lake.

2. Nonpoint sources -

It is estimated that nonpoint sources, including precipitation, contributed 54.0% of the total phosphorus load to Elsworth Lake during the sampling year. East Cache Creek contributed 29.7% of the total load, and Chandler Creek and Mission Creek contributed 1.8% and 4.3%, respectively. Ungaged drainage areas were estimated to have contributed 20.1% of the total phosphorus load.

The phosphorus export rates of the gaged tributaries to Elsworth Lake (range of 3-8 kg P/km^2/yr, mean of 5 kg P/km^2/yr) compare favorably with the tributary rates of nearby Fort Cobb Reservoir* (range of 8-13 kg P/km^2/yr, mean of 11 kg P/km^2/yr).

*See "Preliminary Report on Fort Cobb Reservoir."

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake surface area and mean depth were provided by the Oklahoma Department of Pollution Control; maximum depth was provided by the Oklahoma Water Resources Board. Tributary flow data were provided by the Oklahoma District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 22.66 km^2.
2. Mean depth: 5.1 meters.
3. Maximum depth: 18.3 meters.
4. Volume: 115,566 x 10^6 m^3.
5. Mean hydraulic retention time: 509 days (1.4 yrs).

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries

Name	Drainage area (km²)	Mean flow (m³/sec)
A-2 East Cache Creek	164.2	1.06
B-1 Chandler Creek	26.9	0.16
C-1 Mission Creek	40.9	0.23
Minor tributaries and immediate drainage	386.5	2.88
Totals	618.5	4.26
2. Outlet - A-1 East Cache Creek	642.3	2.83

C. Precipitation:

1. Year of sampling: 85.7 cm.
2. Mean annual: 80.3 cm.

III. LAKE WATER QUALITY SUMMARY

Ellsworth Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake (Stations 03 and 04 were only sampled twice) and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll *a* analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 10.7 meters at Station 01, 6.1 meters at Station 02, 12.5 meters at Station 03, and 4.6 meters at Station 04. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll *a* determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	N	MEAN	MEDIAN	MIN-MAX	N	MEAN	MEDIAN	MIN-MAX	N	MEAN	MEDIAN	MIN-MAX
TEMPERATURE, AIR (DEG C)												
0-1.5 M DEPTH	4	11.7	13.0	10.2 - 12.3	4	24.2	25.0	23.4 - 25.4	4	26.7	26.9	26.0 - 27.2
MID DEPTH	2	11.5	12.8	10.2 - 12.1	3	23.6	24.5	20.1 - 24.1	4	26.4	26.9	25.7 - 27.2
DISSOLVED OXYGEN (MG/L)												
0-1.5 M DEPTH	4	10.0	10.2	9.1 - 10.5	4	9.0	9.2	7.8 - 9.8	4	8.2	8.3	7.6 - 8.6
MID DEPTH	2	9.9	10.1	9.7 - 10.1	3	9.0	8.9	8.1 - 9.8	3	8.0	8.0	7.6 - 8.4
CONDUCTIVITY (UMHOS)												
0-1.5 M DEPTH	4	272	285	259 - 288	4	476	504	466 - 504	4	384	386	367 - 399
MID DEPTH	2	334	335	333 - 335	3	478	482	466 - 486	4	387	390	367 - 399
pH (STANDARD UNITS)												
0-1.5 M DEPTH	4	7.9	8.0	7.8 - 8.0	4	8.2	8.3	8.0 - 8.3	4	8.4	8.4	8.3 - 8.5
MID DEPTH	2	7.9	8.0	7.8 - 8.0	3	8.2	8.3	8.1 - 8.3	3	8.3	8.4	8.1 - 8.4
TOTAL ALKALINITY (MG/L)												
0-1.5 M DEPTH	4	141	156	113 - 158	4	156	168	142 - 168	4	135	140	127 - 140
MID DEPTH	2	145	154	136 - 154	3	154	156	151 - 156	3	135	140	126 - 140
TOTAL P (MG/L)												
0-1.5 M DEPTH	4	0.033	0.033	0.030 - 0.036	4	0.032	0.035	0.028 - 0.035	4	0.030	0.030	0.028 - 0.032
MID DEPTH	2	0.034	0.034	0.032 - 0.036	3	0.033	0.035	0.029 - 0.035	3	0.030	0.030	0.028 - 0.032
DISSOLVED ORTHO P (MG/L)												
0-1.5 M DEPTH	4	0.025	0.026	0.023 - 0.027	4	0.025	0.027	0.022 - 0.027	4	0.024	0.024	0.022 - 0.026
MID DEPTH	2	0.026	0.026	0.025 - 0.027	3	0.025	0.027	0.022 - 0.027	3	0.024	0.024	0.022 - 0.026
NO3+NO2 (MG/L)												
0-1.5 M DEPTH	4	0.010	0.010	0.010 - 0.010	4	0.029	0.030	0.010 - 0.030	4	0.030	0.030	0.030 - 0.030
MID DEPTH	2	0.010	0.010	0.010 - 0.010	3	0.027	0.030	0.010 - 0.030	3	0.030	0.030	0.030 - 0.030
AMMONIA (MG/L)												
0-1.5 M DEPTH	4	0.038	0.038	0.036 - 0.040	4	0.039	0.040	0.036 - 0.040	4	0.035	0.035	0.030 - 0.040
MID DEPTH	2	0.039	0.039	0.038 - 0.040	3	0.040	0.040	0.038 - 0.040	3	0.035	0.040	0.030 - 0.040
ALKALINITY (MG/L)												
0-1.5 M DEPTH	4	0.559	0.565	0.548 - 0.565	4	0.539	0.540	0.538 - 0.540	4	0.540	0.540	0.538 - 0.540
MID DEPTH	2	0.557	0.557	0.548 - 0.565	3	0.539	0.540	0.538 - 0.540	3	0.540	0.540	0.538 - 0.540
SECCHI DISC (METERS)												
2	1.2	1.2	1.2	4	1.0	1.0	1.1	4	1.2	1.2	1.2	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THAT DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/01/74	1. Chroomonas	2,532
	2. Chrysotamonas	1,080
	3. Ankistrodesmus	675
	4. Cyanedra	401
	5. Melosira	334
	Other genera	101
	Total	5,131
06/10/74	1. Carteria	1,805
	2. Chlamydomonas	790
	3. Cryptomonas	664
	4. Stephanodiscus	480
	5. Ankistrodesmus	188
	Other genera	877
	Total	4,813
10/24/74	1. Carteria	1,352
	2. Melosira	230
	3. Stephanodiscus	201
	4. Chroomonas	116
	5. Oocystis	86
	Other genera	144
	Total	2,128

f. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a ug/l
04/01/74	01	7.7
	02	11.3
	03	****
	04	****
06/10/74	01	3.1
	02	1.5
	03	1.7
	04	11.3
10/24/74	01	9.5
	02	12.3
	03	4.6
	04	21.0

E. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked - 04/01/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.016	0.084	0.1
0.05 P	0.060	0.084	6.8
0.05 P + 1.0 N	0.060	1.084	15.7
1.00 N	0.016	1.084	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary production was low in Ellsworth Lake during the time of sampling. The addition of orthophosphorus alone produced a significant increase in yield over that of the control, indicating the sample was phosphorus limited at that time. The addition of nitrogen alone did not result in any increase in yield over that of the control, while the simultaneous addition of both nutrients produced maximum increase in yield over the control. It should be noted that significant nutrient losses occurred in assay samples prior to analysis; the results should not be considered representative of growth responses in the lake.

The autumn assay sample was broken during shipment, so is not included in this report.

The mean inorganic nitrogen to orthophosphorus (N/P) ratios in the lake data were 9/1 and ~4/1 in the spring and fall, respectively, suggesting primary limitation by nitrogen at those times. The summer N/P ratio was 14/1, suggesting phosphorus limitation (a mean N/P of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix B for data)

For the determination of nutrient loadings, the Oklahoma National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of April and May when two samples were collected. Sampling was begun in November 1974, and was completed in October 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Oklahoma District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/yr$, in Chandler Creek and Mission Creek at Stations B-1 and C-1, and multiplying the means by the ZZ area in km^2.

The operators of the Fletcher and Apache wastewater treatment plants provided monthly effluent samples and corresponding flow data.

A. Waste Sources:

1. Known municipal -

Name	Population Served*	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Fletcher	950	Stabilization pond	0.213	Tony Creek/ East Cache Creek
Apache	1,600	Stabilization pond	0.637	Cache Creek

2. Known industrial - None

*Treatment plant questionnaires.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 East Cache Creek	1,245	22.7
B-1 Chandler Creek	90	1.6
C-1 Mission Creek	235	4.3
b. Minor tributaries and immediate drainage (nonpoint load) -	1,545	28.1
c. Known municipal STP's -		
Fletcher	160	2.9
Apache	1,020	18.1
d. Septic tanks* -	5	0.1
e. Known industrial - None		
f. Direct precipitation** -	395	7.2
Totals	5,495	100.0
2. Outout - A-1 East Cache Creek	4,665	
3. Net annual P accumulation -	830	

*Estimate based on 15 lakeshore residences.
**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source		kg N/yr	% of total
a.	Tributaries (nonpoint load) -		
	A-2 East Cache Creek	34,500	21.1
	B-1 Chandler Creek	4,915	3.0
	C-1 Mission Creek	10,445	6.4
b.	Minor tributaries and immediate drainage (nonpoint load) -	84,645	51.7
c.	Known municipal STP's -		
	Fletcher	520	0.3
	Apache	3,960	2.4
d.	Septic tanks* -	160	0.1
e.	Known industrial - None		
f.	Direct precipitation** -	24,485	15.0
	Totals	163,610	100.0
2.	Output - A-1 East Cache Creek	89,635	
3.	Net annual N accumulation -	73,975	

*Estimate based on 15 lakeshore residences.
**Estimated (see NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
East Cache Creek	8	210
Chandler Creek	3	103
Mission Creek	6	266

E. Mean Nutrient Concentration in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
D-1 Tahoe Creek	0.196	3.805
E-1 Unnamed Outlet	0.132	1.986

f. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1973). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Elsworth Lake	0.24
Vollenweider's "eutrophic" loading	0.38
Vollenweider's "oligotrophic" loading	0.19

V. LITERATURE REVIEWED

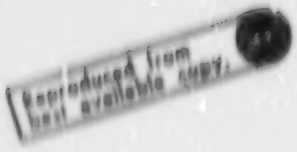
Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS



CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

APPENDIX C

PHYSICAL AND CHEMICAL DATA

[illegible]

[illegible]

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
04/11/82	09	15	[illegible]		[illegible]	[illegible]	[illegible]
04/12/82	11	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/01/82	13	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/02/82	14	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/03/82	09	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/04/82	13	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/04/82	14	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/05/82	12	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/05/82	17	45	[illegible]		[illegible]	[illegible]	[illegible]
05/06/82	13	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/07/82	13	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/08/82	13	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/09/82	09	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05/11/82	14	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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DATE	TIME	DEPTH	GAGE HEIGHT	STREAM FLOW, INSTANTANEOUS	WATER TEMPERATURE	BAROMETRIC PRESSURE	SPECIFIC CONDUCTANCE	DISSOLVED OXYGEN
FEB								
75		FEET						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF OKLAHOMA

LAKE DATA TO BE USED IN ANALYSIS

LAKE CODE	LAKE NAME	MEAN DEPTH, m	MEAN DEPTH, meters	VOLUME m^3	MEAN CALCIUM	Ca MIN MG	MEAN ALKALINITY, meters
4302	ALTUS RESERVOIR	6.041	6.041	449,625	14.756	8.408	8.018
4870	BANKSALE LAKE	6.828	8.878	463,406	7.627	24.689	8.859
4412	LAKE ELLSWORTH	6.137	6.179	454,406	8.438	9.481	8.889
4734	LAKE FAIRFIELD	3.841	6.485	442,513	4.363	24.298	8.826
4225	FORT SUPPLY RESERVOIR	6.139	8.118	454,667	24.867	8.488	8.812
4933	FORT YUMA RESERVOIR	6.478	6.135	485,187	9.733	7.898	8.814
4217	FORT SMITH RESERVOIR	6.927	8.848	463,857	4.862	8.418	8.884
4214	LAKE MANATEE	6.142	2.781	484,333	7.473	8.288	8.893
4335	BANKS LAKE OF THE DESERT	6.987	6.741	469,857	6.788	24.886	8.834
4211	LAKE HEFNER	6.85"	8.258	462,889	5.867	8.482	8.838
4722	KEYSTONE RESERVOIR	6.136	8.498	484,383	22.427	24.488	8.846
4133	DRUSSA LAKE	8.859	8.598	483,888	5.137	24.488	8.838
4123	TENKILLER FERRY RESERVOIR	8.894	8.558	438,588	8.844	25.388	8.824
4724	LAKE TWINEMAHO	8.827	8.257	485,886	8.422	12.888	8.889
4814	WESTERN RESERVOIR	8.986	8.238	478,588	4.812	25.888	8.836
4874	TEXOMA LAKE	8.845	8.288	488,875	12.325	24.882	8.826

HEIGHT OF LAKES <IN <UNIT> VALUES (NUMBER OF LAKES <IN <UNIT> VALUES)

LAKE CODE	LAKE NAME	<TOTAL> TOTAL #	<TOTAL> INCHES	<SQ> MILES SEC	<CUB> CALIBRE	25- MILES	<MILES> DEPTHS P
<001	ALTUS <RESERVOIR	60 (91	166 (251	47 (71	13 (20	66 (111	73 (111
<002	<WASHOE LAKE	166 (251	66 (131	93 (141	53 (80	33 (46	93 (141
<003	LAKE <<<<<<<<	66 (121	86 (131	46 (121	33 (53	66 (46	67 (171
<004	LAKE <<<<<<	20 (30	33 (53	27 (46	166 (251	47 (73	33 (53
<005	POLT <<<< <<<<<<<	73 (111	73 (111	87 (131	7 (11	66 (111	67 (101
<006	POLT <<<< <<<<<<<	33 (53	67 (161	3 (61	27 (41	126 (251	66 (61
<007	POST <<< <<<<<<<	67 (161	53 (121	66 (91	87 (131	66 (111	166 (261
<00<	LAKE <<<<<<	9 (61	8 (61	7 (11	47 (73	93 (141	7 (11
<00<	<<<< LAKE <> THE <<<<<	13 (21	7 (11	41 (61	66 (96	26 (31	13 (71
<010	LAKE <<<<	47 (71	46 (61	67 (161	73 (111	67 (101	26 (71
<011	<<<<<< <<<<<<	7 (11	13 (21	13 (21	6 (61	13 (21	6 (61
<012	WILSON LAKE	46 (61	26 (31	26 (31	46 (113	33 (46	27 (41
<013	<<<<<<<< <<<< <<<<<<	67 (11<	27 (41	166 (251	67 (161	3 (61	56 (71
<01<	LAKE <<<<<<<<	87 (131	66 (91	73 (61	46 (67	53 (61	46 (171
<015	<<<< <<<<<<	27 (41	47 (71	33 (53	93 (141	3 (61	46 (61
<016	TEXAS LAKE	53 (61	53 (61	13 (113	26 (31	33 (46	56 (71